

## HAWAIIAN SPIDERS OF THE GENUS *TETRAGNATHA*: IV NEW, SMALL SPECIES IN THE SPINY LEG CLADE

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**ABSTRACT.** This study continues documentation of the adaptive radiation of species in the genus *Tetragnatha* in the Hawaiian archipelago. The five new species described here are representatives of the ‘spiny-leg’ clade, most representatives of which have already been described. The new species are *T. kukuiki*, *T. kikokiko*, *T. anuenue*, *T. kukuhaa*, and *T. obscura*. The species described are found in various different habitat types from low (e.g., 550 m on Oahu) to middle elevations (1660 m on Hawaii), and from dry to very wet forest types. As with other representatives of the clade, they are nocturnal hunters, do not build webs, and move actively around the vegetation.

**Keywords:** Hawaii, *Tetragnatha*, spiny, descriptions

The Hawaiian island chain is the most isolated archipelago in the world, and as such is well known for having numerous autochthonous radiations of closely related species (Simon 1987; Wagner & Funk 1995; Roderick & Gillespie 1998). Groups of spiders that appear to have undergone extensive species radiations in the islands include *Tetragnatha* Latreille 1804 (Tetragnathidae) (Karsch 1880; Simon 1900; Okuma 1988; Gillespie 1991, 1992), *Mecaphesa* Simon 1900 (Thomisidae) (Simon 1900; Suman 1970; Lehtinen 1993; Garb 1999), *Argyrodes* Simon 1864 (Theridiidae) (Simon 1900), *Theridion* Walckenaer 1805 (Theridiidae) (Simon 1900), and a lineage of jumping spiders (Salticidae) (Gillespie et al. 1998).

This paper is the fourth in a series documenting the radiation of *Tetragnatha* spiders in the archipelago. These species, in common with other endemic arthropods in Hawaii, are characterized by small population sizes (Howarth & Ramsay 1991). Also, in common with other adaptive radiations, they have differentiated rapidly (Gillespie 1999), and on the basis of ecological parameters (Gillespie et al. 2001). Because ecological affinity cannot be preserved, diagnosis must be based on a combination of sexual characters (cheliceral armature and genitalia). All sexual characters show some variation in most species of *Tetragnatha* (Levi 1981). Here, I will attempt to point out the diagnostic features of these structures within the range of variation.

The species described here are all small and do not build webs. Evidence from molecular characters (mitochondrial DNA) (Gillespie 1999) suggests that all five species belong within the now well-recognized ‘spiny-leg’ clade of Hawaiian *Tetragnatha* (12 described species, Simon 1900; Gillespie 1991). In addition, morphological and ecological characters unite these species with the spiny leg clade. These characters include long spines on the legs (similar to those found in species such as *T. laqueata* L. Koch 1872 from the western Pacific (Okuma 1980) and *T. viridis* Walckenaer 1841 from eastern North America (Levi 1981) although more robust in Hawaiian spiny leg species), and an active nocturnal foraging style without a web.

### METHODS

**Characters examined.**—Morphological measurements taken were the same as those described in Gillespie (1991, 1992, 1994): arrangement of eyes (i.e. lens and associated visual pigment); cheliceral tooth pattern; form and setation of the first and third legs (I & III representing the greatest divergence in leg function); and form and pattern of the dorsum, venter, carapace and sternum. In order to estimate variability within a taxon and determine which features best characterize a species, where possible measurements were taken on six individuals of each sex of each species with additional observations on other individ-



Table 1.—Glossary of terms and abbreviations used in text, illustrated in Figs. 1, 2, 7, 80.

Term	Explanation
a	dorsal cheliceral spur (apophysis) used in locking female fang during mating
AX1	auxiliary guide tooth of lower row; small tubercle (may be absent or almost tooth-like) on distal retromargin of chelicerae
CITR	cheliceral inter-tooth ratio; ratio of 3 lengths: (1) between distal end of male chelicerae to sl; (2) sl to T; and (3) T to rsu1
Co, CoP	Conductor cap (Fig. 7, 80); Conductor cap projection (Fig. 80)
fl	setation on femur I
fIII	setation on femur III
G1	guide tooth of lower row; from distal end of chelicera retromargin of the chelicerae, first major tooth
Gu	small tubercle (may be absent or almost tooth-like) on distal promargin of chelicerae
L1-Ln	numbers of chelicera retromargin teeth in female, from distal end
L2	second tooth on chelicera retromargin in female, from distal end
L3	third tooth on chelicera retromargin in female, from distal end
mI	setation on metatarsus I
mIII	setation on metatarsus III
n/n/n	format for numbers of prolateral/dorsal/retrolateral macrosetae
rsu	remaining proximal teeth on promargin of chelicerae, besides sl and T
S1	from distal end of chelicera promargin, first major tooth on promargin
T	from distal end of chelicera promargin, second tooth, often quite large

uals once diagnostic characters had been identified. Genitalia of both sexes were examined using the methods described in Gillespie (1991).

**Terminology.**—The terminology for the teeth on the cheliceral margins of the males is that used in previous papers (Gillespie 1991, 1992, 1994; see Okuma 1987, 1988, see Table 1, Figs. 1, 2, 8). The majority of the speci-

mens were collected by me (RGG), A.C. Medeiros (ACM), C. Parrish (CP), W.D. Perreira (WDP), and D.J. Preston (DJP), and George Roderick (GKR). All holotypes have been deposited in the Bishop Museum, and all paratypes will be deposited in the Essig Museum of Entomology of the University of California, Berkeley. Unless indicated otherwise, all measurements are in mm.

KEY TO SPECIES

1. Males ..... 2

Females ..... 6
2. Conductor cap height greater than length of projection from cap; Figs. 78, 79; see Fig. 80 for terminology); leg spines not very distinctive; abdominal and cheliceral marking distinctive; legs distinctly banded ..... 3

Conductor cap more wide than high (Figs. 77, 80–81); leg spines very distinctive; abdominal and cheliceral markings drab; legs not distinctly banded ..... 4
3. Conductor cap angular (Fig. 79); dorsal tooth of chelicerae very long (approx. 20% length of carapace); spiders very colorful in life, with yellow background coloration and polymorphism in amounts of red, black superimposed (Fig. 37) ..... *T. anuenue*

Conductor cap curved smoothly over (Fig. 78). Dorsal tooth of chelicerae quite short (approx. 12% length of carapace). Spiders not highly colored, patterns mostly of black/gray, white and dark red; no conspicuous color polymorphism ..... *T. kikokiko*
4. Conductor cap very angular, bent round, with projection resembling beak of parrot (Fig. 77) ..... *T. kukuiki*

Conductor cap not angular ..... 5



- 5. Projection from cap of conductor drawn to smooth point (Fig. 80). Dorsal spur usually with shallow bifurcation (Fig. 49) . . . . . *T. kukuhaa*  
Projection from cap of conductor very long, curls over at tip (Fig. 81). Dorsal spur usually blunt (Fig. 64) . . . . . *T. obscura*
- 6. Bulbs of seminal receptacles approximately at right angles to each other, the posterior lateral to the anterior bulb, forming a distinct “C” shape (Fig. 15) . . . . . *T. kukuiki*  
Bulbs of seminal receptacles approximately on the same plane . . . . . 7
- 7. Either anterior or posterior bulb of seminal receptacles oval (Figs. 30, 46). Leg spines not very distinctive. Abdominal and cheliceral marking distinctive. Legs distinctly banded. Abdomen drawn up in dome-shaped, pointed at posterior . . . . . 8  
Bulbs of seminal receptacles subspherical (Figs. 61, 76). Leg spines distinctive. Abdomen not domed. Abdomen with distinct dark mark at center and rounded at posterior margin . . 9
- 8. Enlarged oval posterior bulb of seminal receptacles (Fig. 46). Medial side of tarsus I with 3/4 spines (Fig. 42); teeth on lower side of cheliceral margin spread out, tooth area covering approx. 35% length of chelicerae (Fig. 40); number of teeth on lower side of cheliceral margin > number on upper side; spiders very colorful in life, with yellow background coloration and variable amounts of red and black superimposed (Figs. 44, 45) . . . *T. anuenue*  
Enlarged oval anterior bulb of seminal receptacles (Fig. 30). Medial side of tarsus I with 1/2 spines (Fig. 26); teeth on lower side of cheliceral margin very close together, tooth area covering approx. 25% length of chelicerae (Fig. 24); number of teeth on lower side of cheliceral margin ≤ number on upper side; Spiders not highly colored, patterns mostly of black/gray, white and dark red; no conspicuous color variants (Figs. 28, 29) . . . . *T. kikokiko*
- 9. Anterior bulb of seminal receptacles larger, posterior bulb smaller and more lateral (Fig. 61). Leg spines very long (Fig. 57); lateral and medial eyes separated by almost their width (Fig. 56) . . . . . *T. kukuhaa*  
Bulbs of seminal receptacles paraxial, lateral slightly smaller than medial (Fig. 76). Leg spines not very long (Fig. 72); lateral and medial eyes separated by half their width (Fig. 71) . . . . . *T. obscura*

*Tetragnatha kukuiki* new species  
(Figs. 1–15, 77)

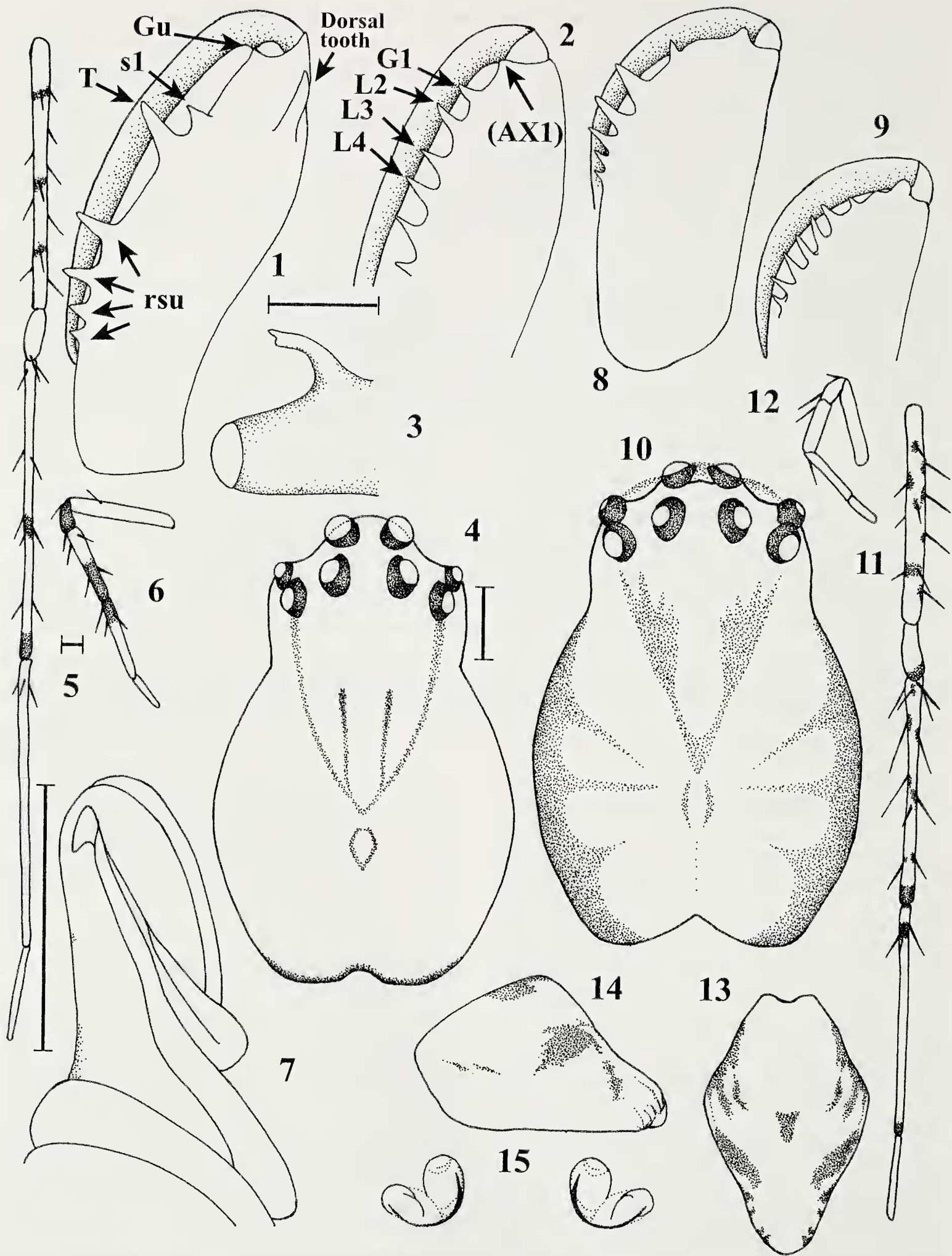
**Type.**—Holotype male from Oahu, Mt. Kaala, 550 m, coll. R.G. Gillespie and G.K. Roderick, 13 August 1995; allotype female from Oahu, Pahole, 600 m, coll. R.G. Gillespie and G.K. Roderick, 19 August 2000, deposited in the Bishop Museum, Honolulu.

**Etymology.**—*Kukū* (Hawaiian) spiny; *iki* (Hawaiian) small. The specific epithet is a noun in apposition. This species was the first of the “small spiny” species to be recognized, and hence was assigned this name.

**Diagnosis.**—*Tetragnatha kukuiki* can be confused with very small immature *T. quasimodo* Gillespie 1991, but is much smaller at maturity (total length approximately 4 compared to 6–8 in *T. quasimodo*). Male *T. kukuiki* are distinguished from all other spiny-leg taxa on the basis of the shape of the conductor cap (wide and angular).

**Description.**—*Holotype male* (Figs. 1–7): Length of carapace 1.6, total length 4.4. Chelicerae 1.0 (63% length of carapace). Chelic-

eral fang slightly shorter than base, bent over at both proximal and distal ends. Promargin of chelicerae (Fig. 1): distance between Gu and s1 much greater than between s1 and T, C/ITR 0.4:0.2:0.4; Gu absent; s1 stout point bent slight towards base of chelicerae, width 40% length (approximately 41% width and 43% height of T); T tall peak (height 0.08) pointing out at a slight angle from margin of chelicerae; rsu 3–4 straight spikes. Retromargin of chelicerae (Fig. 2): total of 6 teeth; AX1 absent; G1 medium-sized, L2 larger; L3–L5 similar in size, L6 smaller. Dorsal spur quite long (length 0.32), curved over (20 % length of carapace); tip unequally bifurcate (Fig. 3). Coloration and eye pattern similar to female (Fig. 4). Legs banded below many of spines and at distal margins of leg segments (Figs. 5, 6). Leg setation: fl 3/3/5; tl 4/1/4; ml 1/1/1; flll 0/2/0, and tlll 2/2/2 and mlll 1/1/1. Leg spines not exceptionally long, mean length of spines on tl, 0.25. Conductor (Figs. 7, 77): conductor cap simple; not highly peaked, drawn out to point.



Figures 1–15.—*Tetragnatha kukuiki*; Male holotype. 1. Promargin of right chelicera; 2. Retromargin of left chelicera; 3. Dorsal spur of chelicera, lateral view; 4. carapace, dorsal; 5. Right leg I, dorsal; 6. Right leg III, prolateral; 7. Left palp. Female allotype. 8. Promargin of right chelicera; 9. Retromargin of left chelicera; 10. Carapace, dorsal; 11. Right leg I, dorsal; 12. Right leg III, prolateral; 13. Abdomen, dorsal; 14. Abdomen, lateral; 15. Seminal receptacles, ventral. Scale bars = 0.5; that at Fig. 1 applies to Figs. 1–3; at Fig. 4 to Fig. 4; at Fig. 5 to Figs. 5, 6; at Fig. 7 to Fig. 7, and at Fig. 8 to Fig. 8. For abbreviations, see glossary, Table 1.



*Allotype female* (Figs. 8–15): Length of carapace 1.5, total length 4.8. Chelicerae slightly less than half length of carapace. Cheliceral fang just over half length of base, tapering to smooth point distally. Promargin of chelicerae (Fig. 8): 6 teeth, U1 short (length 0.03), much narrower and shorter (35%) than U2, separated from U2 by 14% cheliceral length; U2 fairly large, 0.10; U3 of similar height, U4–U6 decreasing in size proximally. Retromargin of chelicerae (Fig. 9): series of 7 teeth: L1 slightly smaller than U1, 50% height and fairly well separated from L2. Remaining retromarginal teeth decreasing in size proximally. Eyes slightly larger than distance separating them. Median ocular area slightly wider posteriorly (Fig. 10); lateral eyes contiguous. Carapace pale brown with dark margins, and additional dark marks converging on thoracic fovea; sternum dusky. Abdomen raised to a peak, height 2.0; dorsum marked with black on pale brown background (Figs. 13–14); venter speckled silver with brown medial, longitudinal bar. Legs with pronounced spots below spines, and at distal margins of each joint (Figs. 11–12). Leg setation: fl 2/3/2; tl 4/2/4; mI 1/1/1; fIII 0/0/0, tIII 0/1/0 and mIII 0/1/0. Leg spines long, mean length of spines on tl, 0.59. Seminal receptacles (Fig. 15): Posterior bulb lateral to anterior bulb, slightly smaller than anterior; both elongate oval in shape.

**Variation.**—( $n = 2\sigma, 4\varphi$ ) *Male*: Carapace 1.4–1.8. CTR no variation, 0.4:0.2:0.4. Up to 8 teeth on retromargin of chelicerae. Tip of dorsal spur can be equally bifurcate. Color patterns vary slightly; no polymorphism. *Female*: Length of carapace 1.4–1.7. Promargin of chelicerae: series of 6–7 teeth. Leg setation: fl variable numbers of setae.

**Natural history.**—*Tetragnatha kukuiki* is found in low elevation mesic forest on Oahu. This forest is currently dominated by alien vegetation, primarily strawberry guava and eucalyptus. The specimens were found actively moving around in the branches of the trees.

**Paratypes.**—Oahu, Mt. Kaala, 550 m, RGG and GKR, 13 August 1995, 1 male; Oahu, Pahole, 600 m, JE Garb, 20 May 1999, 1 male. Oahu, Pahole, 600 m, RGG and GKR, 19 August 2000, 4 females.

*Tetragnatha kikokiko* new species  
(Figs. 16–30, 78)

**Types.**—Holotype male, allotype female from Maui, Auwahi, 1250 m, coll. R.G. Gil-

lespie and A.C. Medeiros, 18 August 1997, deposited in the Bishop Museum, Honolulu.

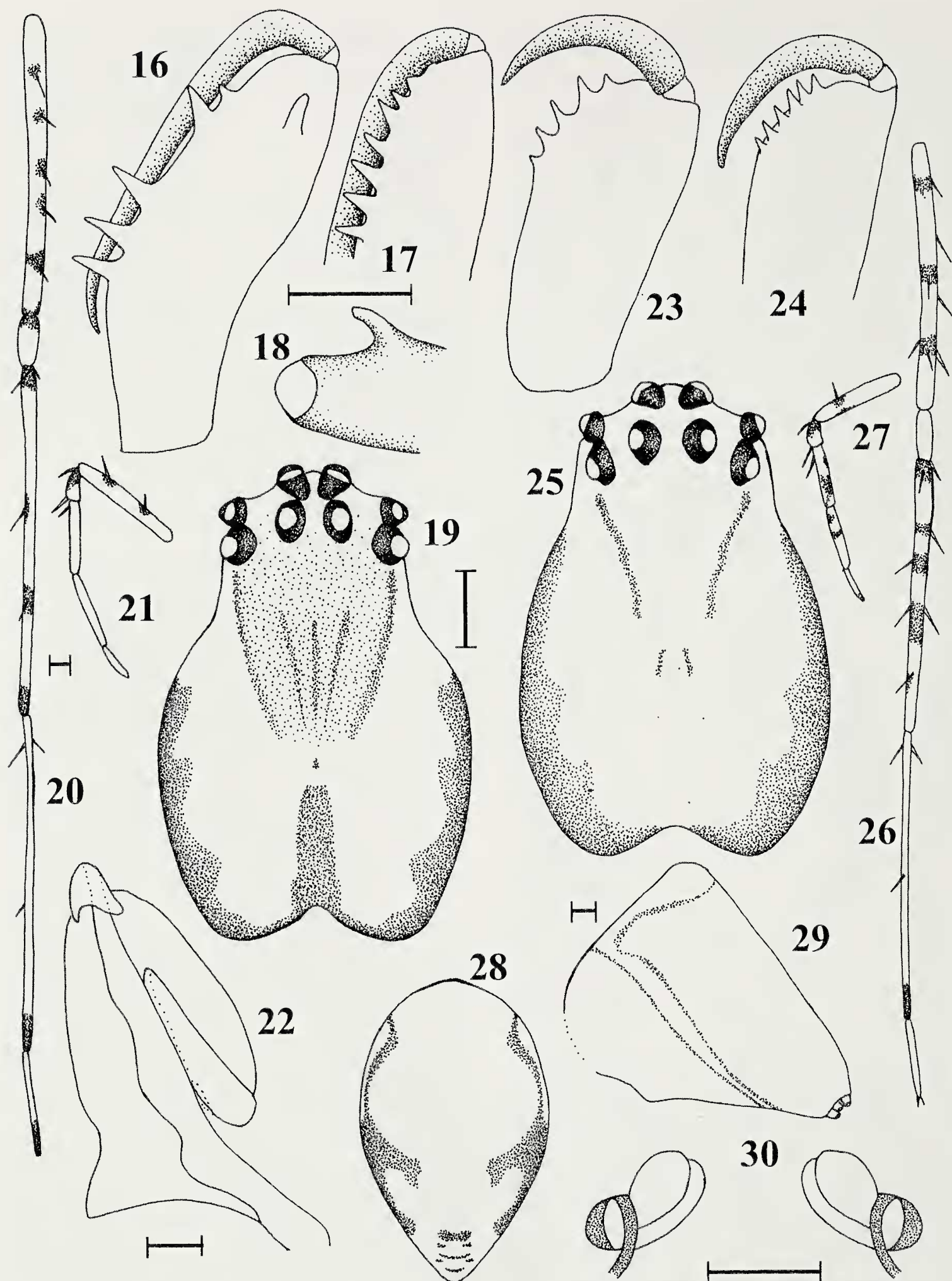
**Etymology.**—*Kikokiko* (Hawaiian) spotted or banded; refers to the very conspicuous banded legs of these small spiders. The specific epithet is a noun in apposition.

**Diagnosis.**—*Tetragnatha kikokiko* is most easily confused with *T. restricta* Simon 1900 and small immature *T. quasimodo*. Compared to *T. quasimodo*, *T. kikokiko* is much smaller in size at maturity (female length 3.5–4.5 compared to 6–8 in *T. quasimodo*), the eyes are larger and closer together, and the spines shorter. The abdomen is pointed (not raised up along a medial flat line across abdomen as in *T. restricta*) and without a prominent central black mark (as in *T. quasimodo*). It can also be distinguished from all other spiny-leg taxa by the shape of the conductor cap (high and smoothly curved).

**Description.**—*Holotype male* (Figs. 16–22): Length of carapace 1.4, total length 3.6. Chelicerae 0.8 (57% length of carapace). Cheliceral fang slightly shorter than base, bent over at both proximal and distal ends. Promargin of chelicerae (Fig. 16): distance between Gu and s1 much greater than between s1 and T, CTR approx. 0.4:0.2:0.4, reflecting close proximity of s1 and T and large separation of T from rsu; Gu indistinct or absent; s1 prominent point, width about half length (approximately 70% width and 45% height of T); T not very large (height 0.05) or wide, pointing straight out from margin of chelicerae; rsu 3 straight spikes, first few similar in size or even larger, than T. Retromargin of chelicerae (Fig. 17): total of 7 teeth; AX1 absent or indistinct; G1 small, L2–L7 showing slight increase in size proximally. Dorsal spur quite short (length 0.15), bent (11 % length of carapace); tip flat-faced (Fig. 18). Thoracic fovea indistinct “V”-shaped depression. Coloration and eye pattern as in female (Fig. 19). Abdomen less elevated than female. Leg setation similar to female (Figs. 20, 21). Conductor (Figs. 22, 78): conductor cap quite broad and not highly peaked, drawn out to point; stem curved over to form short flange projecting behind cap.

*Allotype female* (Figs. 23–30): Length of carapace 1.3, total length 3.8. Chelicerae just less than half length of carapace. Cheliceral fang quite short (approximately half length of base), tapering to smooth point distally. Pro-





Figures 16–30.—*Tetragnatha kikokiko*; Male holotype. 16. Promargin of right chelicera; 17. Retromargin of left chelicera; 18. Dorsal spur of chelicera, lateral view; 19. carapace, dorsal; 20. Right leg I, dorsal; 21. Right leg III, prolateral; 22. Left palp, prolateral. Female allotype. 23. Promargin of right chelicera; 24. Retromargin of left chelicera; 25. Carapace, dorsal; 26. Right leg I, dorsal; 27. Right leg III, prolateral; 28. Abdomen, dorsal; 29. Abdomen, lateral; 30. Seminal receptacles, ventral. Scale bars for Figs. 16–21 and 23–29, 0.5; scale bars for Figs. 22 & 30, 0.1. That at Fig. 18 applies to Figs. 16–18, 23, 24; at Fig. 19 to Figs. 19, 25; at Fig. 20 to Figs. 20, 21, 26, 27; at Fig. 29 to Figs. 28, 29; and Fig. 22 to Fig. 22; and Fig. 30 to Fig. 30.



margin of chelicerae (Fig. 23): 5 teeth, U1 short (length 0.02), almost as wide but shorter (60%) and close to (9% cheliceral length) U2 and U3; U2 not large, 0.04; U3 of similar height, U4–U5 decreasing in size proximally. Retromargin of chelicerae (Fig. 24): series of 6 teeth: L1 taller than U1, similar in size and very close to L2. Remaining retromarginal teeth decreasing in size proximally. Eyes larger than distance separating them. Median ocular area slightly wider posteriorly (Fig. 25); lateral eyes contiguous. Carapace brown with dark margins, and pair of dark lines running from behind PLE's and converging broadly towards fovea; sternum dusky. Abdomen raised towards medial point, height 2.1; dorsum brown with dark margins, converging towards posterior (Figs. 28, 29); venter speckled silver with brown medial, longitudinal bar. Legs with large dark spots or bands below each spine and at distal margins of each joint (Figs. 26, 27. Leg setation: fl 0/3/2; tI 2/2/2; mI 1/0/1; fIII 0/1/0, tIII 0/1/0 and mIII 0/0/0. Leg spines not exceptionally long, mean length of spines on tI, 0.28. Seminal receptacles (Fig. 30): enlarged oval anterior bulb; smaller, more lateral, posterior bulb.

**Variation.**—( $n = 6\delta, 6\eta$ ) Male: Carapace 1.2–1.5. CITR little variation, 0.4:0.2:0.4; rsu up to 4. Tip of dorsal spur can be slightly indented. Female: Length of carapace 1.2–1.5. Promargin of chelicerae up to 7 teeth. Color patterns vary slightly; no polymorphism. Leg setation similar within Auwahi, but in Waikamoi: fl 1/3/4; tI 3/1/2; other setation patterns similar.

**Natural history.**—*Tetragnatha kikokiko* is found in dry and mesic forest at middle elevations on East Maui. Populations have been found in remnant dry forest of Auwahi on the south slope of East Maui, a small dryland community on unweathered lava with little soil formation. It is also found in mesic forest on the north slope of East Maui at the western side of the Nature Conservancy of Hawaii's Waikamoi Preserve. Individuals do not build webs. They are found actively moving about and hanging from trees at night.

**Paratypes.**—Maui Island, Auwahi tract: 1100–1250 m, RGG & ACM, 18 August 1997, 2 $\delta$ , 3 $\eta$ . Maui Island, Waikamoi: 1340 m, RGG, 9 November 1996, 2 $\delta$ , 4 $\eta$ ; same area, RGG & ACM, 27 July 1999, 2 $\delta$ , 2 $\eta$ .

*Tetragnatha anuenue* new species  
(Figs. 31–46, 79)

**Types.**—Holotype male from Hawaii Island, Saddle Road, 1530 m, coll. R.G. Gillespie, 12 June 1989; allotype female from Hawaii Island, Puu Makaala, 1215 m, coll. R.G. Gillespie, 14 October 1990; deposited in the Bishop Museum, Honolulu.

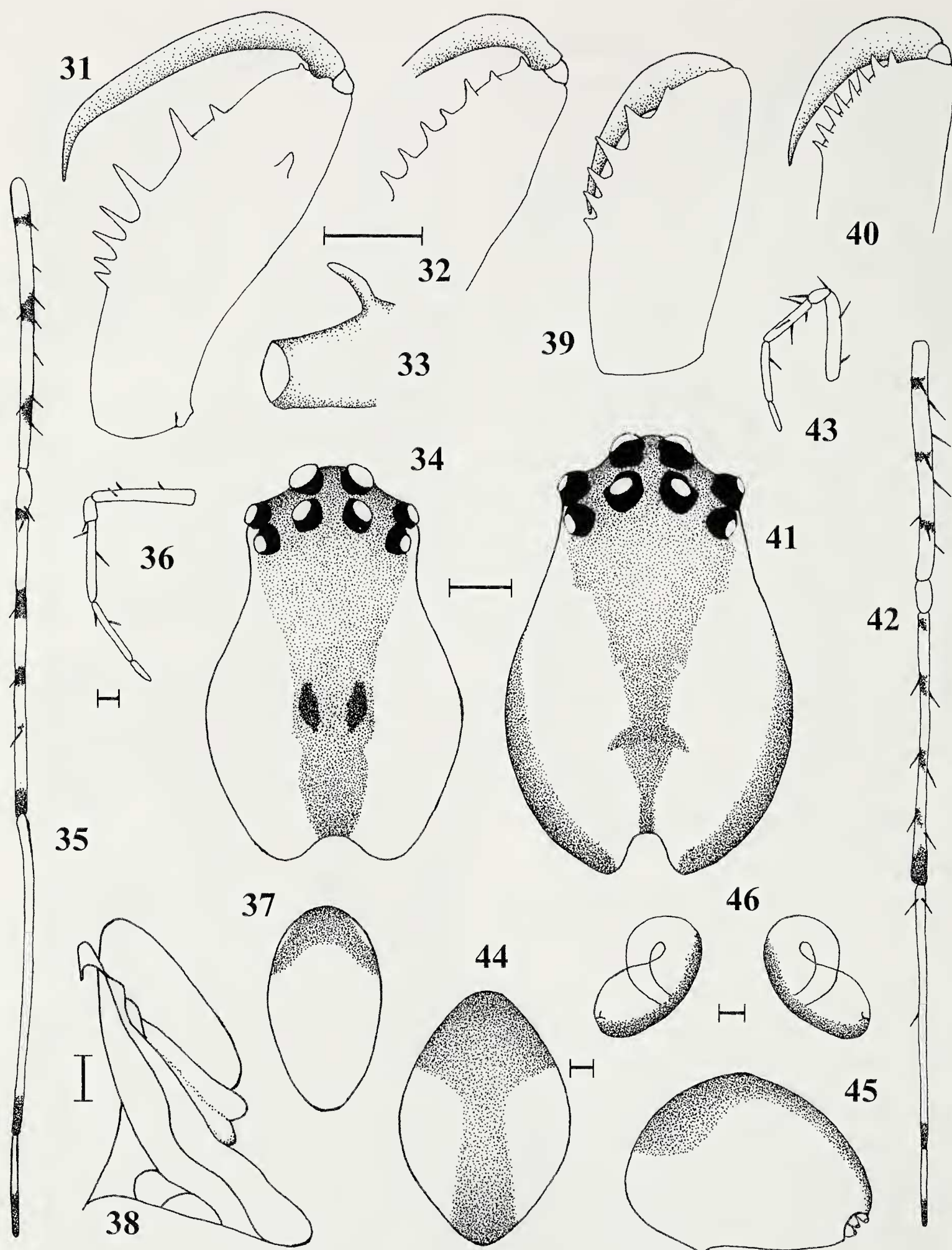
**Etymology.**—*Anuenue* (Hawaiian) rainbow. This refers to the colorful nature of these spiders, with many different bright color morphs. The specific epithet is a noun in apposition.

**Diagnosis.**—*Tetragnatha anuenue* is not easily confused with other species. The animal is generally strikingly patterned, with variable amounts of red or black pigment superimposed on a pale translucent yellow/gold background. It can also be distinguished on the basis of the shape of the conductor cap (high and angular), long dorsal spur, and the female seminal receptacles (enlarged oval posterior bulb).

**Description.**—*Holotype male* (Figs. 31–38): Length of carapace 1.5, total length 3.8. Chelicerae 1.0 (70% length of carapace). Cheliceral fang slightly shorter than base, bent over at both proximal and distal ends. Promargin of chelicerae (Fig. 31): distance between Gu and s1 much greater than between s1 and T, CITR 0.5:0.2:0.3; Gu indistinct or absent; s1 small point, width 42% length (approximately 60% width and 33% height of T); T tall spike (height 0.07) pointing directly out from margin of chelicerae; rsu 5 straight spikes. Retromargin of chelicerae (Fig. 32): total of 6 teeth; AX1 absent or indistinct; G1 small and wide, L2 taller and wider; rest of teeth narrower spikes, L4–L6 similar in height to L2 (L3 shorter). Dorsal spur long (length 0.27), with strong, angular bend (18 % length of carapace); tip pointed (Fig. 33). Thoracic fovea indistinct depression. Dorsum coloration pale yellow/gold with red “U” shape at front (Fig. 37). Eye pattern (Fig. 34) and leg setation (Figs. 35–36) similar to female. Conductor (Figs. 38, 79): conductor cap simple, highly peaked.

*Allotype female* (Figs. 39–46): Length of carapace 1.6, total length 4.3. Chelicerae approx. half length of carapace. Cheliceral fang just over half length of base, tapering to smooth point distally. Promargin of chelicerae





Figures 31–46.—*Tetragnatha anuenue*; Male holotype. 31. Promargin of right chelicera; 32. Retro-marginal teeth of left chelicera; 33. Dorsal spur of chelicera, lateral view; 34. Carapace, dorsal; 35. Right leg I, dorsal; 36. Right leg III, prolateral; 37. Abdomen, dorsal (stippling indicates red coloration); 38. Left palpus, prolateral. Female allotype. 39. Promargin of right chelicera; 40. Retro-marginal teeth of left chelicera; 41. Carapace, dorsal; 42. Right leg I, dorsal; 43. Right leg III, prolateral; 44. Abdomen (stippling indicates red coloration), dorsal; 45. Abdomen, lateral; 46. Seminal receptacles, ventral. Scale bars for Figs. 31–37 & 39–45, 0.5; scale bars for Figs. 38 & 46, 0.1. That at Fig. 33 applies to Figs. 31–33, 39, 40; at Fig. 34 to Figs. 34, 41; at Fig. 35 to Figs. 35, 36, 42, 43; at Fig. 44 to Figs. 37, 44, 45; at Fig. 38 to Fig. 38; and at Fig. 46 to Fig. 46.



(Fig. 39): 6 teeth, U1 short (length 0.03), almost as wide but much shorter (30%) than U2, separated from U2 by 15% cheliceral length; U2 fairly large, 0.09; U3 of similar height, U4–U6 decreasing in size proximally. Retromargin of chelicerae (Fig. 40): series of 8 teeth: L1 approx. same size as U1, 60% height and fairly close to L2. Remaining retromarginal teeth decreasing in size proximally. Eyes considerably larger than distance separating them. Median ocular area slightly wider posteriorly (Fig. 41); lateral eyes contiguous. Carapace pale yellow with dark margins, and dark medial area constricted behind thoracic fovea; sternum dusky. Abdomen smoothly domed, height 1.7; dorsum with red markings on pale speckled gold background (Figs. 44, 45); venter speckled silver with brown medial, longitudinal bar. Legs banded below many spines, and at distal margins of each joint (Fig. 42). Leg setation: fl 1/4/5; tl 3/2/4; ml 2/0/1; fIII 0/2/0, tIII 1/1/1 and mIII 0/0/1. Leg spines not notably long, mean length of spines on tl, 0.39. Seminal receptacles (Fig. 46): Enlarged elongate oval posterior bulb; smaller, more medial, anterior bulb.

**Variation.**—( $n = 6\delta$ ,  $6\eta$ ) *Male*: Carapace 1.5–1.9. CTR little variation. 0.5:0.2:0.3; rsu 4–5. Retromargin of chelicerae 6–8 teeth. *Female*: Length of carapace 1.4–1.8. Carapace variable pale yellow or brown with dark margins, and variable dark medial. Highly polymorphic markings of black, brown and red, on speckled gold background of dorsum. Banding on legs of variable intensity. Leg setation: fl variable; tl 3/1/3; ml 2/0/1; fIII sometimes 2 dorsal.

**Natural history.**—*Tetragnatha anuenue* is found in middle elevation wet forest on Hawaii Island. It is a beautiful animal in life, exhibiting striking color polymorphism of red and black patterns superimposed on a yellow background (Figs. 37, 44, 45 depict 2 patterns, although the colors fade in alcohol). Individuals do not build webs and are generally found hanging from trees at night.

**Paratypes.**—Hawaii Island, Mauna Kea-Mauna Loa Saddle: Kipuka 6–8, Saddle Road, 1540–1600 m, RGG & CP, 25 July 1988, 3 $\delta$ , 4 $\eta$ , and RGG, 12 June 1989, 2 $\eta$ , and RGG & CP, 11 January 1991, 1 $\eta$ ; Kipuka 9, Saddle Road, 1530 m, RGG & CP, 4 January 1991, 10 $\delta$ , 8 $\eta$ , and WDP, 1 April 1991, 1 $\eta$ ; Kipuka at mile 21–22, 1660 m, RGG & JI Gillespie,

12 March 1990, 1 $\eta$ ; Wailuku River, 1067 m, RGG & CP, 12 July 1988, 1 $\eta$ ; Kipuka, Saddle Road, 823 m, RGG & CP, 25 July 1988, 1 $\delta$ ; Puu Makaala, 1222 m, RGG and JI Gillespie, 17 March 1990, 2 $\eta$ , 1 $\delta$ ; and RGG, DJP, and I Felger 14 October 1990, 7 $\eta$ , 6 $\delta$ , and RGG and CP, 3 January 1991, 3 $\eta$ , and RGG, 29 July 1991, 1 $\eta$ , 2 $\delta$ ; and 4300ft, RGG, DJP, and I Felger, 21 October 1990, 1 $\delta$ , 4 $\eta$ ; Lupaohoe, 1257 m (1 $\eta$ , 1 $\delta$ ), 976 m (1 $\eta$ ), and 700m (1 $\eta$ ), 19 October 1990, RGG, DJP, & J. Burgett.

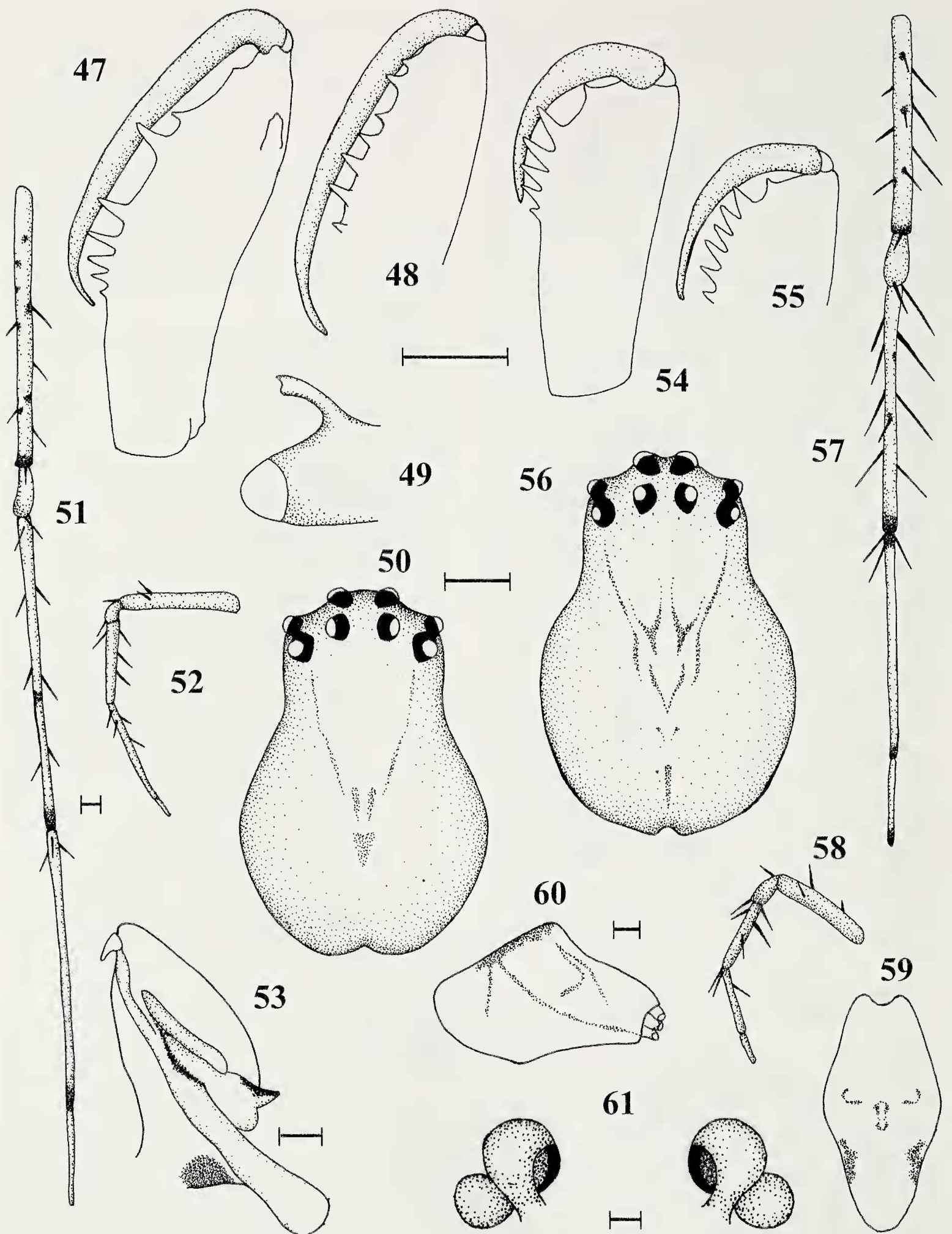
***Tetragnatha kukuhaa* new species**  
(Figs. 47–61, 80)

**Types.**—Holotype male, allotype female from Hawaii Island, Puu Waawaa, 1215 m, coll. R.G. Gillespie and J. Giffin, 12 February 1997, deposited in the Bishop Museum, Honolulu.

**Etymology.**—*Kukū* (Hawaiian) spiny; *ha'a* (Hawaiian) dwarf. The specific epithet is a noun in apposition.

**Diagnosis.**—*Tetragnatha kukuhaa* is most easily confused with *T. restricta* and small immature *T. quasimodo*. Compared to *T. quasimodo*, it is smaller in size at maturity (female length 5 compared to 6–8 in *T. quasimodo*). The abdomen is pointed (not raised up along a medial flat line across abdomen as in *T. restricta*). Other features that distinguish the species from all other spiny-leg taxa include the cheliceral dentition and the shape of the conductor cap (wide with projection drawn to a smooth point) and seminal receptacles (bulbs subspherical, anterior bulb larger).

**Description.**—*Holotype male* (Figs. 47–53): Length of carapace 1.9, total length 4.8. Chelicerae 1.4 (75% length of carapace). Cheliceral fang slightly shorter than base, bent over at both proximal and distal ends. Promargin of chelicerae (Fig. 47): distance between Gu and s1 twice as much or more than distance between s1 and T, CTR 0.5:0.2:0.3; Gu indistinct or absent; s1 fairly prominent point, projecting from margin at a slight angle towards the base of the chelicerae, width approx. 40% length (approx. 40% width and height of T); T large (height 0.09), robust peak; rsu 5 almost straight spikes. Retromargin of chelicerae (Fig. 48): total of 7 teeth; AX1 absent or indistinct; G1 similar in size to L3 and both are much shorter than remain-



Figures 47–61.—*Tetragnatha kukuhaa*; Male holotype. 47. Promargin of right chelicera; 48. Retromargin of left chelicera; 49. Dorsal spur of chelicera, lateral view; 50. carapace, dorsal; 51. Right leg I, dorsal; 52. Right leg III, prolateral; 53. Left palpus, prolateral. Female allotype. 54. Promargin of right chelicera; 55. Retromargin of left chelicera; 56. Carapace, dorsal; 57. Right leg I, dorsal; 58. Right leg III, prolateral; 59. Abdomen, dorsal; 60. Abdomen, lateral; 61. Seminal receptacles, ventral. Scale bars for Figs. 47–52 & 54–60, 0.5; scale bars for Figs. 53 & 61, 0.1. That at Fig. 54 applies to Figs. 47–49, 54, 55; at Fig. 50 to Figs 50, 56; at Fig. 51 to Figs. 51, 52, 57, 58; at Fig. 60 to Figs. 59, 60; at Fig. 53 to Fig. 53; and at Fig. 61 to Fig. 61.



ing retromarginal teeth; L2, L4, L5 and L6 all large spikes. Dorsal spur long (0.38, approx. 20% carapace length), tip bifurcated (Fig. 49). Thoracic fovea indistinct “V” shape. Coloration and eye pattern as in female. Leg setation similar to female (Figs. 51, 52). Conductor (Figs. 53, 80): conductor cap simple, not highly peaked; apex pointed.

**Allotype female** (Figs. 54–61): Length of carapace 2.0, total length 5.1. Chelicerae just more than half length of carapace. Cheliceral fang approx. half length of base, tapering to smooth point distally. Promargin of chelicerae (Fig. 54): series of 6 teeth; U1 robust (length 0.04), much shorter (30%) and well separated from (18 % cheliceral length) U2 and U3; U2 large, length 0.13, and U3 only very slightly shorter; U4–U6 decreasing in size proximally. Retromargin of chelicerae (Fig. 55): series of 6 teeth decreasing in size proximally: L1 similar in height to U1, about 30% height of L2 and well separated from L2. Eyes approx. same size as distance separating them; median ocular area wider posteriorly (Fig. 56); lateral eyes contiguous. Carapace brown with “V”-shaped fovea; sternum dusky. Abdomen raised to low peak at midline, height 1.7; dorsum brown with black marks in front and behind wider and higher medial area (Figs. 59, 60); venter speckled silver with brown medial, longitudinal bar. Legs brown with dark spots around femoral spines and dark bands at distal margins of each joint (Figs. 57, 58). Leg setation: fl 3/3/3; tl 4/1/4; ml 1/1/1; fIII 0/2/1, tIII 1/1/1 and mIII 0/1/1. Leg spines long, mean length of spines on tl, 0.95. Seminal receptacles (Fig. 61): anterior bulb larger, posterior bulb smaller and more lateral.

**Variation.**—( $n = 3 \delta, 3 \text{♀}$ ) *Male*: Carapace 1.7–2.0. CTR can be 0.4:0.2:0.4; rsu 4–5. Retromargin of chelicerae 6–7 teeth. *Female*: Length of carapace 1.8–2.1. Promargin of chelicerae: series of 5–7 teeth. Leg setation: fl may be 3/3/5; tIII sometimes 2 prolateral macrosetae.

**Natural history.**—*Tetragnatha kukuhaa* has only been collected in the dry forest of Puu Waawaa, where it is found moving among, and hanging from, branches of trees.

**Paratypes.**—Hawaii Island, Puu Waawaa 1040 m, RGG, 12 February 1997, 2 $\delta$ , 2 $\text{♀}$ .

*Tetragnatha obscura* new species  
(Figs. 62–76, 81)

**Types.**—Holotype male, allotype female from Hawaii Island, Kahaualea, 515 m, coll.

R.G. Gillespie, 2 January 1991, deposited in the Bishop Museum, Honolulu.

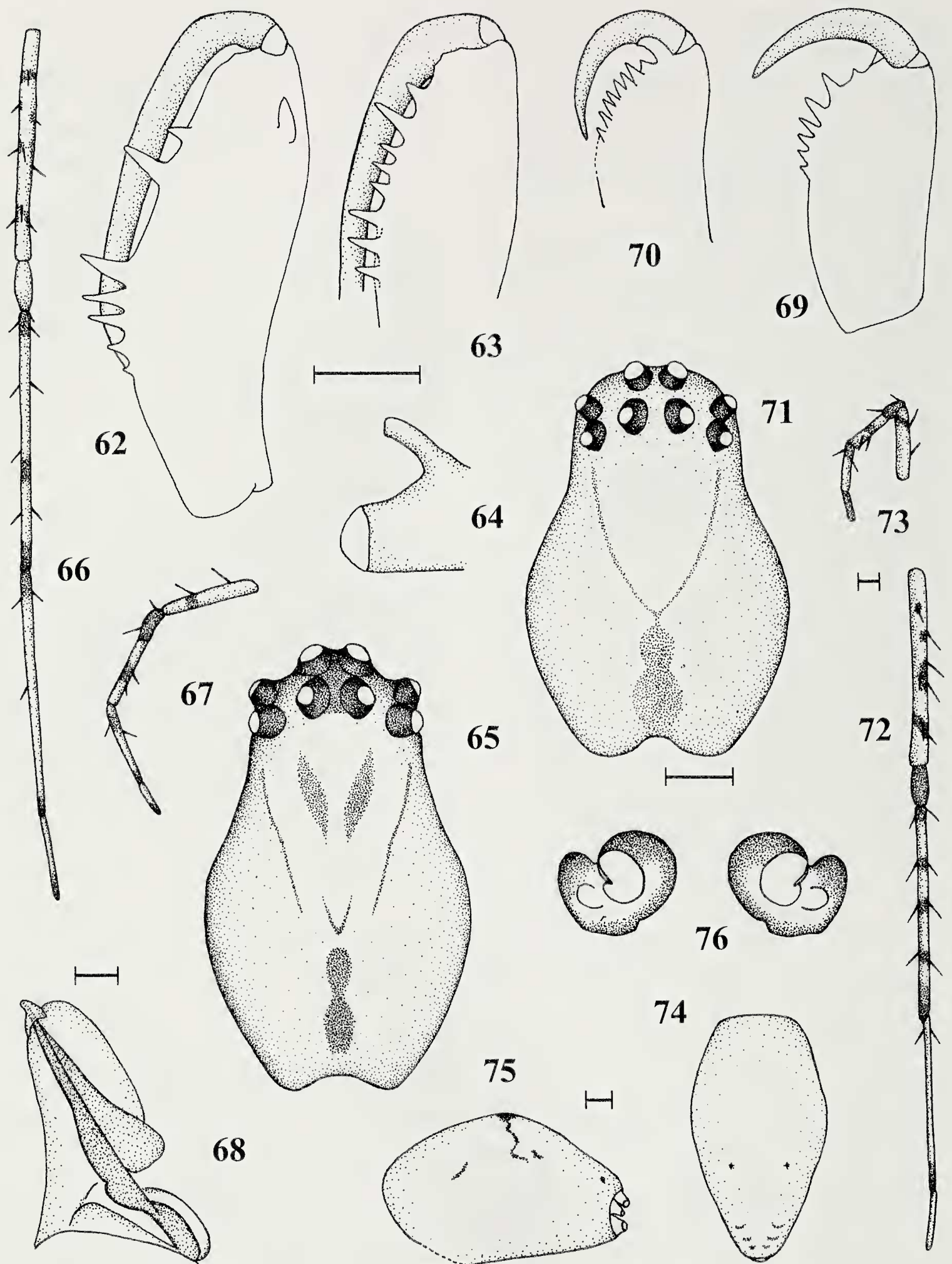
**Etymology.**—*Obscurus* (Latin) obscure or inconspicuous. The specific epithet is an adjective and refers to the small size and brown coloration of these spiders, which combine to make them rather inconspicuous.

**Diagnosis.**—*Tetragnatha obscura* is most similar to small *T. quasimodo*, but is smaller in size (approximate female length 4 compared to 6–8 in *T. quasimodo*), the abdomen is not raised to a medial peak, and the eyes are relatively larger and closer together. Other features that distinguish it from all other spiny-leg taxa include the cheliceral dentition and the shape of the conductor cap and seminal receptacles.

**Description.**—*Holotype male* (Figs. 62–68): Length of carapace 1.6, total length 3.9. Chelicerae 70% length of carapace. Cheliceral fang slightly shorter than base, bent over at both proximal and distal ends. Promargin of chelicerae (Fig. 62): distance between Gu and s1 much greater than between s1 and T, CTR 0.4:0.2:0.4; Gu indistinct or absent; s1 fairly prominent point, projecting straight out from margin of chelicerae, width approx. 44% length (approx. 70% width and 40% height of T); T large (height 0.07), robust point; rsu 5 almost straight spikes. Retromargin of chelicerae (Fig. 63): total of 8 teeth; AX1 absent or indistinct; G1 a robust spike, similar in height but wider than L3–L8. L2 long, almost twice as long as any of other retromarginal teeth. L3–L8 show slight increase in size proximally. Dorsal spur medium length (length 0.26, approx. 16 % carapace length), almost straight, and with blunt tip that may show slight bifurcation (Fig. 64). Thoracic fovea longitudinal depression. Coloration and eye pattern as in female. Leg setation similar to female (Figs. 66, 67). Conductor (Figs. 68, 81): conductor cap simple; apex pointed.

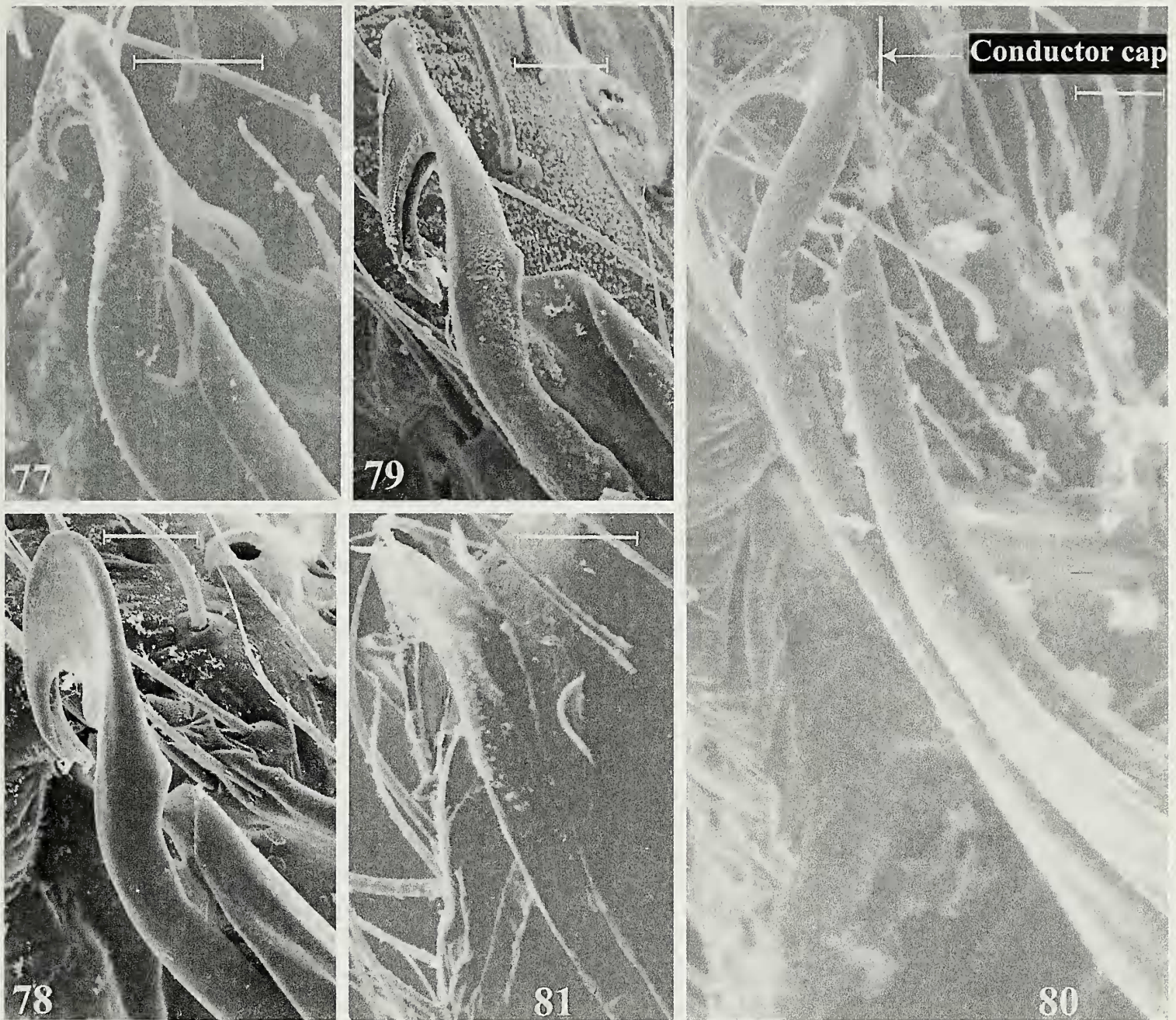
**Allotype female** (Figs. 69–76): Length of carapace 1.4, total length 3.7. Chelicerae just less than half length of carapace. Cheliceral fang approx. half length of base. Promargin of chelicerae (Fig. 69): series of 7 teeth; U1 robust (length 0.03), shorter (40%) and close to (10 % cheliceral length) U2 and U3; length of U2 0.07, U3 only very slightly shorter; U4–U6 decreasing in size proximally. Retromargin of chelicerae (Fig. 70): series of 8 teeth





Figures 62–76.—*Tetragnatha obscura*; Male holotype. 62. Promargin of right chelicera; 63. Retromargin of left chelicera; 64. Dorsal spur of chelicera, lateral view; 65. carapace, dorsal; 66. Right leg I, dorsal; 67. Right leg III, prolateral; 68. Left palpus, prolateral. Female allotype. 69. Promargin of right chelicera; 70. Retromargin of left chelicera; 71. Carapace, dorsal; 72. Right leg I, dorsal; 73. Right leg III, prolateral; 74. Abdomen, dorsal; 75. Abdomen, lateral; 76. Seminal receptacles, ventral. Scale bars for Figs. 62–67 & 69–75, 0.5; scale bars for Figs. 68 & 76, 0.1. That at Fig. 63 applies to Figs. 62–64, 69, 70; at Fig. 71 to Figs 65, 71; at Fig. 72 to Figs. 66, 67, 72, 73; at Fig. 75 to Figs. 74, 75; at Fig. 68 to Figs. 68, 76.





Figures 77–81.—Scanning electron micrographs of conductor tips of male palps (scale bar on each represents 20  $\mu\text{m}$ ): 77. *T. kukuiki*; 78. *T. kikokiko*; 79. *T. anuenue*; 80. *T. kukuhaa*; 81. *T. obscura*; Co, Conductor cap; CoP, Conductor cap projection.

decreasing in size proximally: L1 similar in height to U1, about 40% height of L2 and almost contiguous with L2. Eyes considerably larger than distance separating them; median ocular area slightly wider posteriorly (Fig. 71); lateral eyes contiguous. Carapace brown with dark margins, dark lines converging from behind posterior lateral eyes to thoracic fovea. Thoracic fovea wide longitudinal bar; sternum dusky. Abdomen raised very slightly to low peak at midline, height 1.4; dorsum brown with medial black mark and paired lateral black marks just in front and behind the midline, and paired chevron marks at posterior (Figs. 74, 75); venter speckled silver with brown medial, longitudinal bar. Legs brown with dark spots around spines and dark bands at distal margins of tibia, metatarsus and tarsus (Figs. 72, 73). Leg setation: fl 0/3/3; tl 2/

2/1; mI 1/0/1; fIII 0/2/0, tIII 0/0/1 and mIII 0/1/1. Leg spines short, mean length of spines on tI, 0.25. Seminal receptacles (Fig. 76): bulbs paraxial, lateral slightly smaller than medial. Bulbs compact, pushed together.

**Variation.**—( $n = 3\delta, 3\eta$ ) *Male*: Carapace 1.3–1.7. Little variation in CITR; rsu 4–5. Retromargin of chelicerae 7–8 teeth. *Female*: Length of carapace 1.4–1.6. Promargin of chelicerae: series of 6–7 teeth. Leg setation: fl may be 1/1/3; tl 3/1/3; fIII can have 1 dorsal macrosetae.

**Natural history.**—*Tetragnatha obscura* has been found only in the wet forest at low elevations on Hawaii island, in the Kahaualea natural area reserve, Puna, on the east slope of Mauna Loa.

**Paratypes.**—Hawaii Island, Kahaualea, 515 m, RGG & DJP, 2 January 1991, 2 $\delta$ , 2 $\eta$ .



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## LITERATURE CITED

- Garb, J. E. 1999. An adaptive radiation of Hawaiian Thomisidae: Biogeographic and genetic evidence. *Journal of Arachnology* 27:71–78.
- Gillespie, R. G. 1991. Hawaiian spiders of the genus *Tetragnatha*. I. Spiny leg clade. *Journal of Arachnology* 19:174–209.
- Gillespie, R. G. 1992. Hawaiian spiders of the genus *Tetragnatha* II. Species from natural areas of windward East Maui. *Journal of Arachnology* 20:1–17.
- Gillespie, R. G. 1999. Comparison of rates of speciation in web-building and non-web-building groups within a Hawaiian spider radiation. *Journal of Arachnology* 27:79–85.
- Gillespie, R. G., F. G. Howarth, & G. K. Roderick. 2001. Adaptive Radiation. Pages 25–44 in S. A. Levin, editor. *Encyclopedia of Biodiversity*. Academic Press, New York.
- Gillespie, R. G., M. A. Rivera, & J. E. Garb. 1998. Sun, surf and spiders: taxonomy and phylogeography of Hawaiian Araneae. Pages 41–51 in P. A. Selden, editor. *17th European Colloquium of Arachnology*. British Arachnological Society, Burnham Beeches, Bucks, Edinburgh.
- Howarth, F. G. & G. W. Ramsay. 1991. The conservation of island insects and their habitats. in N. M. Collins, Thomas, J.A., editor. *The Conservation of Insects and Their Habitats*. Academic Press, London.
- Karsch, F. 1880. Mittheilung über die von Herrn Dr. O. Finsch während seiner polynesischen Reise gesammelten Myriapoden und Arachniden. *Sitzungsberichte der Gesellschaft naturforschender Freunde zu Berlin* 1880:77–83.
- Lehtinen, P. T. 1993. Polynesian Thomisidae—A meeting of old and new world groups. *Memoirs of the Queensland Museum* 33:585–591.
- Levi, H. W. 1981. The American orb-weaver genus *Dolichognatha* and *Tetragnatha* north of Mexico (Araneae: Araneidae, Tetragnathinae). *Bulletin of the Museum of Comparative Zoology Harvard* 149:271–318.
- Okuma, C. 1980. Notes on a spider, *Tetragnatha laqueata* L. Koch, 1871 of the Bonin Islands, Japan (Araneae, Tetragnathidae). *Esakia*, 15:75–78.
- Okuma, C. 1988. Redescriptions of the Hawaiian spiders of *Tetragnatha* described by Simon (Araneae, Tetragnathidae). *Journal of the Faculty of Agriculture Kyushu University* 33:77–86.
- Roderick, G. K. & R. G. Gillespie. 1998. Patterns of speciation and phylogeography of Hawaiian arthropods. *Molecular Ecology* 7:519–531.
- Simon, C. 1987. Hawaiian evolutionary biology: An introduction. *Trends in Ecology and Evolution* 2:175–178.
- Simon, E. 1900. Arachnida. Pages 443–519, pls. 415–419 in D. Sharp, editor. *Fauna Hawaiiensis*. Cambridge University press, Cambridge.
- Suman, T. W. 1970. Spiders of the family Thomisidae in Hawaii. *Pacific Insects* 12:773–864.
- Wagner, W. L. & V. A. Funk, editors. 1995. *Hawaiian Biogeography Evolution on a Hot Spot Archipelago*. Smithsonian Institution Press, Washington, DC.

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